

# Kozani-8 Low Enthalpy Geothermal Water Use through a Cascade and Hybrid System

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## Abstract

Albania is relatively rich with low up to the middle enthalpy, with waters coming out as natural springs (12 springs) and wells (10 wells). The water temperature blowing out of the wells varies from 34°C up to 65.5°C to Kozani -8, the most important among the Albanian geothermal wells. It had been drilled in 1989. Finding of the hot brine was considered and “accident” at that time, as the well had been designed and drilled to search oil & gas. The well is located on the hills, 26km SE of Tirana. It encounters limestone strata at 1819m, penetrating over 10m into this section. The yield of the well is 10.3 l/s, and is presented stable from more than 23 years. The geographical position of the well, placed in the middle of a village, very close to the corridor 8, are some of the most important parameters on choosing these waters for our designs and the related calculations. The recreational center provides the cascade and integral use of the Kozani-8 geothermal water, but not only. It also provide the electricity generations, through a hybrid system. The center will be also equipped with SPA, open and closed pools, fitness, massages, greenhouse & also aquaculture pools. The economic analyses, based on the NPV calculations, shows that this resource is completely competitive, and is unjustified it's further “waste”. Despite the fact that the investment is too high (over 5.5 million Euro), it is completely feasible, and this is proven also by the risk analyses. It will also help on improving the living standards for the local community.

## Keywords

Geothermal; Kozani-8; Pool; Temperature; Cascade; Heat Exchanger; Designing; Economics; Integral; Hybrid

## Introduction

The Albanian geothermal springs and wells are located in three different areas: Ishmi-Kruja, Ardenica and Peshkopia. They differ from each-other by geological and thermo-hydrogeological features and characteristics. Each one of them is result of the regional tectonics and seismic activity. The Ishmi-Kruja geothermal zone, Figure 1, is close to the “Mother Teresa” international airport.

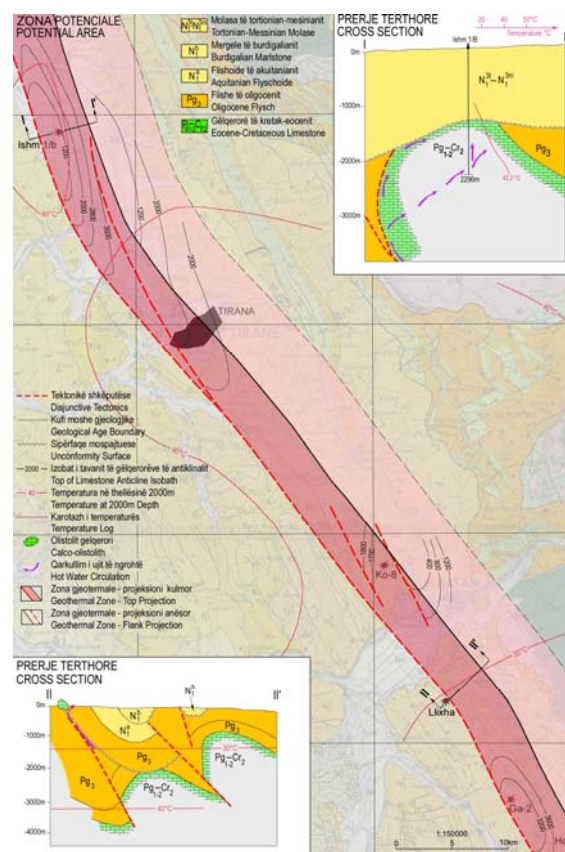


FIGURE 1 MAP OF THE ISHMI-KRUJA GEOTHERMAL ZONE

It is also next to the Kruja historical city, the wonderful Adriatic Sea beaches & Lake of Ohrid. The demonstrative geothermal center, with the cascade and integral use, but also combined with the solar panels (hybrid system), is designed for the Kozani-8 well waters. The choice had been made because of its temperature, on the value of 65.5°C, and yield 10 l/s. In the aquifer top of the well trunk the water is 80°C. Hot water has salinity of (4.6-19.3) g/l. actually all these waters are “wasted”: they flows directly to a creek, meaning high economical loses. Among different processes of the cascade, will be released CO<sub>2</sub> and H<sub>2</sub>S, which will be used for food products (conservation) and medical purposes. The hybrid system, combing of the middle enthalpy geothermal waters, with the solar

panels, based on the fact that the Albanian climate allow such a thing (there are more than 280 sunny days on the area), will improve the economic efficiency of the project.

### The Geological Structure of the Region

Kruja geothermal zone represents a zone with large geothermal resources. The Kruja geothermal zone has a length of 180 km. The Kruja Geothermal Zone extends from the Adriatic Sea in the North and continues down to the South - Eastern area of Albania and to the Konitza area in Greece. The lower geological section extends the Neritic Pelagic carbonate rocks of the Cretaceous-Paleocene while above them lies the Oligocene flysch, which has a thickness of up to 5 km and 180 km length [6]. Main crease of the area became in the middle Oligocene and in the lower and middle Miocene, therefore, there are some transgressed sedimentary section of the upper Oligocene, and especially of the Miocene above the older ones, Figure 2. Geothermal aquifer is represented by a carstified neritic carbonate formation with numerous fissures and micro fissures. Three boreholes produce hot and mineralized water: Ishmi-1/b, Kozani-8 and Galigati-2. The specific electric resistance varies in the levels of 20÷50 Ohm, feature that promise for good formation properties. In fact the effective porosity is 1% and the permeability varies from 0.05÷3.5 mD. The hydraulic conductivity of the limestone section varies between  $8.6 \times 10^{-10}$ ÷ $8.8 \times 10^{-8}$  m/s and the transmissivity ranges from  $8.6 \times 10^{-7}$ ÷ $8.5 \times 10^{-5}$  m<sup>2</sup>/s. Kozani-8 well has been drilled in 1989. Borehole is located on hills 26km SE of Tirana. It encounters limestone strata at 1816 m, penetrating over 10 m into the section. The temperature at the top of aquifer reaches 80°C in the Kozani-8 borehole. Kruja stratigraphic break exists at the level of the Paleocene-Eocene, whose varies from an anticline string to another. This area was built by some anticline and synclinal lines, descending westward. These are linear structure with tens of kilometers of length. Anticline generally has broken in their western side by overlying tectonic, so they are often observed only as monocline with eastern decrease, such as the Dajti-Kruja lines. Along the overlying, limestone and dolomites of the Cretaceous tectonically contact with the Oligocene flysch of the western syncline west, Figure 3. In this area there are three wells that produce hot water (geothermal wells): Ishmi-1/b, Kozani-8 and Galigati-2, Table 1. From the regional point of view, they extend up to the depth of 10 km; above evaporate

which are related to regional tectonics [1]. At this depth the temperature reaches values of 120÷150°C. Water comes from the interval 1816÷1837 m [2]. Temperature at this depth is 80°C while the pressure is about 191 bars. The wellhead pressure is 12 bars, while the temperature is 65.5°C. The total dissolved solids is 4.6 g/l [2], pH= 7.5; the cations  $\text{Ca}^{2+}$ =27.62 mg/l,  $\text{Mg}^{2+}$ =20.4 mg/l,  $\text{Na}^{+}$ = 268.5 mg/l,  $\text{NH}_4^{+}$ =47.5 mg/l; the anions  $\text{Cl}^{-}$ =270.2 mg/l,  $\text{SO}_4^{2-}$ =46.2 mg/l and  $\text{HCO}_3^{2-}$ =10 mg/l; the microelements B=0.00067 µg/l.

TABLE 1 BASIC PARAMETERS OF THE ALBANIAN GEOTHERMAL WELLS

| Well        | Temperature (°C) | Coordinates |           | Yield (l/s) |
|-------------|------------------|-------------|-----------|-------------|
|             |                  | Lat. (V)    | Long. (L) |             |
| Kozani 8    | 65.5             | 41°06'''    | 20°01'6"  | 10.3        |
| Ishmi 1/b   | 60               | 41°29'2"    | 19°40'4"  | 3.5         |
| Letan       | 50               | 41°07'9"    | 20°22'49" | 5.5         |
| Galigati 2  | 45-50            | 40°57'6"    | 20°09'24" | 0.9         |
| Bubullima 5 | 48-50            | 41°19'18"   | 19°40'36" |             |
| Ardenica 3  | 38               | 40°48'48"   | 19°35'36" | 15-18       |
| Semani 1    | 35               | 40°50'      | 19°26'    | 5           |
| Semani 3    | 67               | 40°46'12"   | 19°22'24" | 30          |
| Ardenica 12 | 32               | 40°48'12"   | 19°35'42" |             |
| Verbasi 2   | 29.3             |             |           | 1÷3         |



FIGURE 2 GEOLOGICAL AND HYDROGEOLOGICAL MAP OF THE KRUJA GEOTHERMAL ZONE

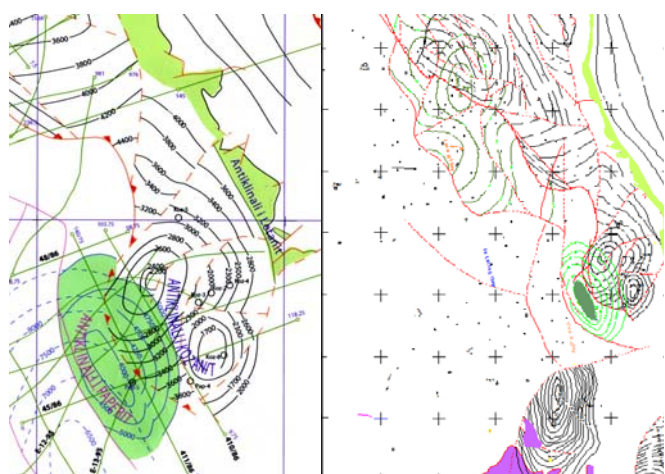


FIGURE 3 STRUCTURAL MAP OF THE KOZANI LIMESTONE AND THEIR SEAL

## Energetic Reserves Evaluation of the Kozani Limestone Structure

The formation heat is calculated through the relation [2] (Table 2):

$$Q_0 = [(1 - \Phi) \cdot \rho_m \cdot c_m + P \cdot \rho_w \cdot c_w] (t_1 - t_0) \cdot A \cdot \Delta z$$

where:  $\Phi$  the effective porosity of the limestone ( $P=5.8 \times 10^{-3}$ );

$\rho_m$  mean density of the matrix ( $\rho_m = 2640 \text{ kg/m}^3$ );

$c_m$  specific heat capacity of the formation ( $c_m = 1.1 \text{ kJ/kgK}$ );

$\rho_w$  water density ( $\rho_w = 980.37 \text{ kg/m}^3$ );

$c_w$  water specific heat ( $c_w = 4.1893 \text{ kJ/kgK}$ );

$t_1$  formation temperature ( $t_1 = 85^\circ\text{C}$ );

$t_0$  ground temperature ( $t_0 = 16.5^\circ\text{C}$ ).

The geothermal energy reserves are calculated through the relation (Table 2):

$$Q_1 = R_0 \cdot Q_0$$

where:  $R_0 = 0.1$  because Kozani-8 is the only well, erupting hot water.

The recoverable geothermal energy is (Table 2):

$$E = Q_v \cdot (t_t - t_r) \cdot \rho_w \cdot c_w \cdot \Delta t$$

The specific reserves are (Table 2):

$$q = \frac{Q_1}{A}$$

The energetic capacity is (Table 2):

$$Q_e = P_{\max} \cdot (t_w - t_g) \cdot 0.004184$$

where:  $P_{\max}$  the maximal yield of the well [l/s];

$t_w$  water temperature [ $^\circ\text{C}$ ];

$t_g$  ground temperature [ $^\circ\text{C}$ ].

The annual energy use is [TJ/y] (Table 2):

$$S_e = P_{av} \cdot (t_w - t_g) \cdot 0.1319$$

where  $P_{av}$  the average yields of the well [kg/s];

The capacity factor is (Table 2):

$$K = 0.03171 \cdot \frac{S_e}{Q_e}$$

TABLE 2 ENERGETIC RESERVES OF KOZANI-8 GEOTHERMAL WELL

| Parameter          | Value                               |
|--------------------|-------------------------------------|
| Formation Heat     | $1.0712 \cdot 10^{10} \text{ [GJ]}$ |
| Energy Reserves    | $1.0712 \cdot 10^9 \text{ [GJ]}$    |
| Recoverable Energy | $2.401 \cdot 10^6 \text{ [GJ]}$     |
| Specific Reserves  | $39.63 \text{ [GJ/m}^2\text{]}$     |
| Energetic Capacity | $2.05 \text{ [MWh]}$                |
| Energy Use         | $0.39 \text{ [TJ/year]}$            |
| Capacity Factor    | 0.006                               |

## The Scheme for the Integral, Cascade and Hybrid Use of the Kozani-8 Geothermal Waters

It was thought by the group of authors, that the best and more efficient way to use the geothermal waters of Kozani-8 well is the constructions of a multicenter [9]. The center will include the SPA, massage and fitness center, open and closed pools (with different sizes and temperatures), greenhouse, aquaculture cultivation pools, conference rooms etc. The center will be heated through the geothermal direct use (through the installation of the heat exchangers) [5], while for the cooling will be installed a geothermal heat pump [3]. The roof, covered with solar panels, whose combination can provide the sanitary water and also a part of them, will circulate the geothermal water and increase its temperature, allowing so the electricity production (the hybrid system). This electricity will serve for the lighting system of the center (green energy). In the Figure 4, is showed the frontal and lateral view of the center, in the Figure 5, the principal sketch of the integral, cascade and the hybrid system, while in the figure 6 is showed the aquaculture cultivation principal sketch.



FIGURE 4 RECREATIONAL CENTRE KOZANI-8, SHIJON



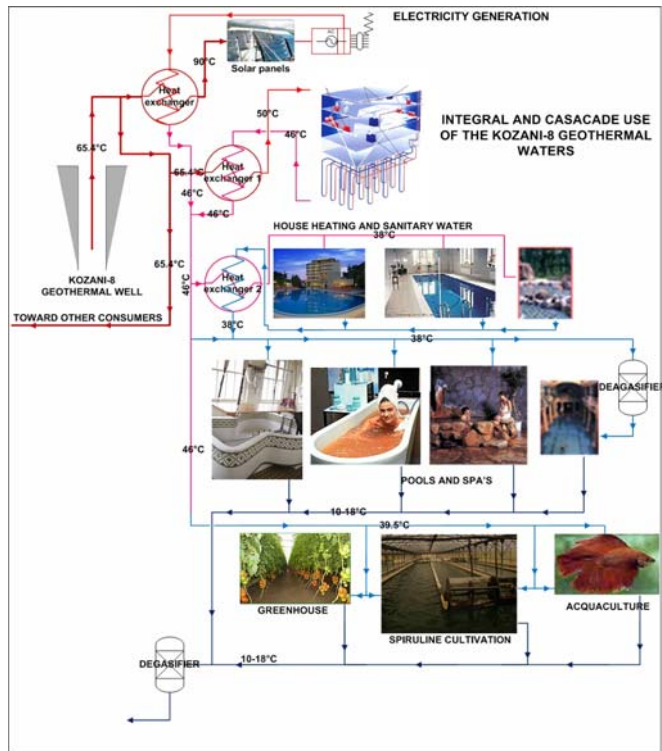


FIGURE 5 PRINCIPAL SKETCH OF THE INTEGRAL, CASCADE AND HYBRID USE OF THE KOZANI-8 GEOTHERMAL WATER USE

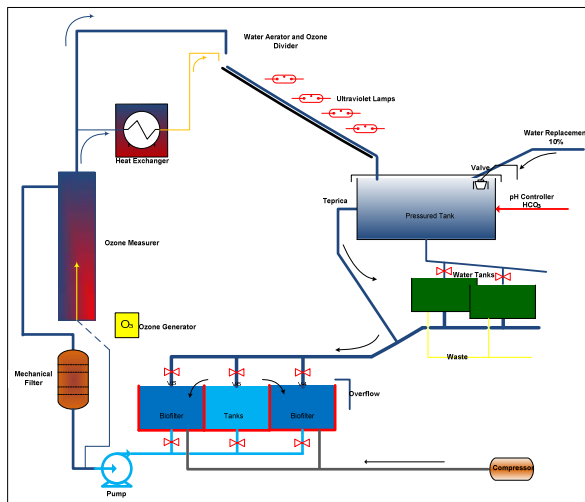


FIGURE 6 AQUACULTURE CULTIVATION PRINCIPAL SKETCH

## Heat Looses

The proposed center will have several pools: 1 geothermal pool (designed as a natural pond, sized 10\*8\*0.5 m, water temperature 38°C-degasified); 1 open Olympic pool (sized 50\*23\*3 m, water temperature 30°C); 1 sweet water pool (sized 10\*5\*1.5 m-escalate, water temperature 38°C-degasified, lightly closed); 1 kids sweet water pool (sized 5\*3\*0.5 m-escalate, water temperature 30°C). The criteria for pool designing are: psychological and physiological comfort, roads width 1-3 m, height of the closed pools

4 m, temperature & humidity level, easy maintenance and the noise level below 60 dB. The thermal loads, based on their nature and effect on the thermal balance, can be calculated as losses or thermal increment. The heat losses of the system are influenced by a number of factors including the number of the guests, their physical activity, the electrical equipment's, solar radiation, natural ventilation, thermo insulation etc. Calculation for the electrical equipment's are made based on the assumption that the maximum load, varies during the day, to avoid their supersizing. In the Figure 7, is showed the water circulation scheme for the pools. On the first cascade the water will be used for house-heating and also for pools. The water discharged by the geothermal and hot water pool (38°C) will be used for the spirulina cultivation. On the first heat exchanger the water supply should be 22.69 t/h of water, for an installed capacity of 512 kW [7]. This amount of energy will be transmitted through the sweet water, heated at the level of 45-50°C. On the second heat exchanger are needed 15 [t/h of water] for an installed capacity of 480 kW. The water temperature in this heat exchanger should be in the range of 40-50°C [7], Figure 8. In the Table 3 are presented the thermal loads for the center for both seasons: winter and summer, while in the Table 4 the parameters of the closed pools environment [8].

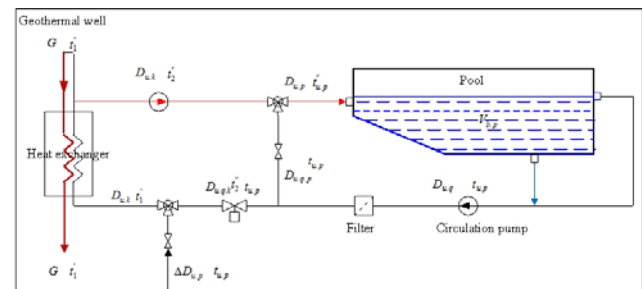


FIGURE 7 THE GEOTHERMAL/FRESH WATER POOLS CIRCULATION SCHEME

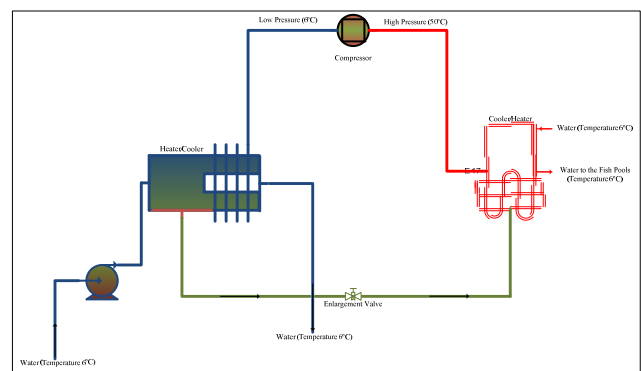


FIGURE 8 HEAT EXCHANGER AND HEAT PUMP SKETCH CENTRE

TABLE 3 SEASONAL THERMAL LOADS OF THE CENTER

| Room/environment         | SUMMER            |          |                     |              |
|--------------------------|-------------------|----------|---------------------|--------------|
|                          | Thermal load [kW] | Air [kW] | Sanitary water [kW] | Total [kW]   |
| Main Building            | 100               | 130      | 53                  | 283          |
| Closed Pools             |                   |          |                     | 130.5        |
| Geothermal Pool (10x8)m  |                   |          |                     | 72           |
| Sweet Water Pool (10x5m) |                   |          |                     | 45           |
| Kids Pool (5x3m)         |                   |          |                     | 13.5         |
| <b>Subtotal</b>          |                   |          |                     | <b>413.5</b> |
| Closed Pool (Water)      |                   |          |                     |              |
| Geothermal Pool (Water)  |                   |          |                     |              |
| Sweet Water Wool         |                   |          |                     |              |
| Olympic Pool (Water)     |                   |          |                     |              |
| <b>Total</b>             |                   |          |                     | <b>413.5</b> |

| Room/environment         | WINTER            |          |                     |               |
|--------------------------|-------------------|----------|---------------------|---------------|
|                          | Thermal load [kW] | Air [kW] | Sanitary water [kW] | Total [kW]    |
| Main Building            | 512               | 420      | 80                  | 1012          |
| Closed Pools             | 32.3              | 63.6     | 130.5               | 226.4         |
| Geothermal Pool (10x8)m  | 18                | 35       | 72                  | 125           |
| Sweet Water Pool (10x5m) | 11                | 22       | 45                  | 78            |
| Kids Pool (5x3m)         | 3.3               | 6.6      | 13.5                | 23.4          |
| <b>Subtotal</b>          |                   |          |                     | <b>1236.4</b> |
| Closed Pool (Water)      |                   |          |                     | 68            |
| Geothermal Pool (Water)  |                   |          |                     | 48            |
| Sweet Water Wool         |                   |          |                     | 20            |
| Olympic Pool (Water)     |                   |          |                     | 1300          |
| <b>Total</b>             |                   |          |                     | <b>2674.4</b> |

TABLE 4 CLOSED POOLS PARAMETERS

| Environment  | Parameter                           |
|--------------|-------------------------------------|
| Closed Pools | $V_{air}=45 [m^3/hm^2]$             |
|              | $Q_{floor}=220 [W/m^2]$             |
|              | $Q_{sanitary\ water}=0.90 [kW/m^2]$ |

## Environmental Analyses and Positive Impact of the Scheme

The environmental effects of the Kozani-8 geothermal well come because of two main reasons:

- High content of gases;
- High content of mineral salts.

The chemical analyses of the water shows that the  $H_2S$  content is 410.07 mg/l,  $H_2SO_4$  43.1 mg/l,  $HBO_2$  25.4 mg/l and free  $CO_2$  184.7 mg/l. Other free elements of

the water in 60°C are Cl, F, Br, J and  $NO_2$  [9]. These entire chemicals are not dissolved in the geothermal water, so it's enough a small perturbation and they can be released to the atmosphere. Most of them are poisoning to the people, except that they are extremely harmful for the equipment. Their actual effect on the environment is high and also the health problem to the community, caused by them is relevant. So it is necessary that all this gases should be removed through and degasing process, Figure 9. The quantitative evaluations shows that the total amount of the gases that should be removed is 5.12 kg/h, for a total mass of geothermal water 12.04 t/h with mean temperature 40.68°C. The mineral saline content of the Kozani-8 water is 4.6 g/l while the pH is 7.5. In big amount are the cations  $Na^+$  1.19 g/l,  $Ca^{2+}$  0.79 g/l,  $Mg^{2+}$  0.2 g/l,  $K^+$  0.17 g/l,  $NH_4^+$  0.02 g/l, traces of  $Fe^{2+}$ , As and  $Cu^{2+}$ ,  $Al^{3+}$  0.2 g/l, traces of heavy metals as Fe, Cu, Al and the anions  $Cl^-$  2.36 g/l,  $SO_4^{2-}$  1.78 g/l,  $HCO_3^-$  0.43 g/l,  $F^-$  0.8 g/l,  $Br^-$  2.4 g/l,  $J^-$  1.1 g/l,  $HS^-$  95.3 g/l,  $S_2O_3^{2-}$  1.5 g/l,  $SO_3^{2-}$  0.1 g/l,  $HPO_4^{2-}$  0.4 g/l, traces of  $NO_2^{1-}$ . The water contain also dry residue (in 180°C) in the level of 6808 mg/l. Their effect extends on pollution of the surface and underground waters, soil pollution, and corrosion and depositions problem while the most important are the human and animal health issues, Figure 9. That's why the proposed scheme predicts to treat this water in order to remove all the pollutant. The purification process will involve the total desalination and as the second step, the selective desalination in order to get the valuable compounds. This scheme will be economically efficient, as part of them have market values, so they will be sold to the national market.

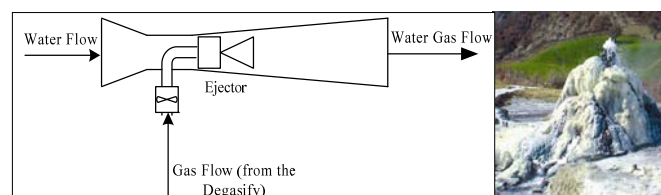


FIGURE 9 DEGASIFY SKETCH AND KOZANI-8 WELLHEAD (SILICA, CALCITE DEPOSITIONS)

## Economical Analyses

In Table 5 is showed some costs data's related with the constructions cost for the Recreational Geothermal Centre & SPA, Shijon, and Elbasan. There can be clearly seen that the biggest investment should be done for the building (66.7%), while that the total investment is calculated to be 5 708 285 Euro [8].

TABLE 5: COSTS CALCULATIONS FOR THE SHIJONI RECREATIVE GEOTHERMAL CENTRE &amp; SPA

| Constituent                  | Investment [€]   |
|------------------------------|------------------|
| Property (land)              | 440 880          |
| Hotel-Clinic                 |                  |
| - Building                   | 3 808 280        |
| - Acclimatize System         | 654 560          |
| - Furniture                  | 229 670          |
| Greenhouse                   | 186 710          |
| Spirulina Cultivation Centre | 252 085          |
| Aquaculture Installations    | 136 100          |
| <b>Total [€]</b>             | <b>5 708 285</b> |

TABLE 6: THE NPV CALCULATIONS FOR DIFFERENT SCENARIOS (BASED IN THE CF)

| Time [years] | Present Value for Different Cash Flow |                  |                  |                 |                 |                 |
|--------------|---------------------------------------|------------------|------------------|-----------------|-----------------|-----------------|
|              | 250000 [€/y]                          | 300000 [€/y]     | 350000 [€/y]     | 400000 [€/y]    | 450000 [€/y]    | 500000 [€/y]    |
| 1            | -5.09E+06                             | -5.05E+06        | -5.00E+06        | -4.95E+06       | -4.91E+06       | -4.86E+06       |
| 2            | -4.67E+06                             | -4.58E+06        | -4.49E+06        | -4.40E+06       | -4.31E+06       | -4.22E+06       |
| 3            | -4.32E+06                             | -4.19E+06        | -4.06E+06        | -3.93E+06       | -3.79E+06       | -3.66E+06       |
| 4            | -4.01E+06                             | -3.84E+06        | -3.67E+06        | -3.50E+06       | -3.33E+06       | -3.16E+06       |
| 5            | -3.73E+06                             | -3.52E+06        | -3.31E+06        | -3.10E+06       | -2.89E+06       | -2.68E+06       |
| 6            | -3.46E+06                             | -3.22E+06        | -2.97E+06        | -2.72E+06       | -2.48E+06       | -2.23E+06       |
| 7            | -3.22E+06                             | -2.93E+06        | -2.65E+06        | -2.36E+06       | -2.08E+06       | -1.79E+06       |
| 8            | -2.98E+06                             | -2.66E+06        | -2.34E+06        | -2.01E+06       | -1.69E+06       | -1.37E+06       |
| 9            | -2.75E+06                             | -2.39E+06        | -2.03E+06        | -1.68E+06       | -1.32E+06       | -959775         |
| 10           | -2.52E+06                             | -2.13E+06        | -1.74E+06        | -1.34E+06       | -950671         | -557274         |
| 11           | -2.31E+06                             | -1.88E+06        | -1.45E+06        | -1.02E+06       | -591445         | -162458         |
| 12           | -2.10E+06                             | -1.63E+06        | -1.17E+06        | -702794         | -238538         | 225717          |
| 13           | -1.89E+06                             | -1.39E+06        | -889616          | -390386         | 108844          | 608073          |
| 14           | -1.68E+06                             | -1.15E+06        | -616532          | -82596          | 451340          | 985275          |
| 15           | -1.48E+06                             | -915709          | -347315          | 221079          | 789472          | 1.36E+06        |
| 16           | -1.29E+06                             | -684191          | -81569           | 521053          | 1.12E+06        | 1.73E+06        |
| 17           | -1.09E+06                             | -455596          | 181041           | 817677          | 1.45E+06        | 2.09E+06        |
| 18           | -900107                               | -229656          | 440796           | 1.11E+06        | 1.78E+06        | 2.45E+06        |
| 19           | -710218                               | -6140            | 697937           | 1.40E+06        | 2.11E+06        | 2.81E+06        |
| 20           | -522379                               | 215148           | 952675           | 1.69E+06        | 2.43E+06        | 3.17E+06        |
| 21           | -336429                               | 434380           | 1.21E+06         | 1.98E+06        | 2.75E+06        | 3.52E+06        |
| 22           | -152225                               | 651708           | 1.46E+06         | 2.26E+06        | 3.06E+06        | 3.87E+06        |
| 23           | 30358                                 | 867264           | 1.70E+06         | 2.54E+06        | 3.38E+06        | 4.22E+06        |
| 24           | 211429                                | 1.08E+06         | 1.95E+06         | 2.82E+06        | 3.69E+06        | 4.56E+06        |
| 25           | 391087                                | 1.29E+06         | 2.20E+06         | 3.10E+06        | 4.00E+06        | 4.90E+06        |
| 26           | 569420                                | 1.50E+06         | 2.44E+06         | 3.37E+06        | 4.31E+06        | 5.24E+06        |
| 27           | 746506                                | 1.71E+06         | 2.68E+06         | 3.65E+06        | 4.62E+06        | 5.58E+06        |
| 28           | 922416                                | 1.92E+06         | 2.92E+06         | 3.92E+06        | 4.92E+06        | 5.92E+06        |
| 29           | 1.10E+06                              | 2.13E+06         | 3.16E+06         | 4.19E+06        | 5.23E+06        | 6.26E+06        |
| 30           | 1.27E+06                              | 2.34E+06         | 3.40E+06         | 4.46E+06        | 5.53E+06        | 6.59E+06        |
| <b>N.P.V</b> | <b>-4.60E+07</b>                      | <b>-2.87E+07</b> | <b>-1.14E+07</b> | <b>5.87E+06</b> | <b>2.32E+07</b> | <b>4.04E+07</b> |

The economic analyses are done based on the Net Present Value (NPV) Calculations. The center will be constructed through a banking loan. Is underlined this fact, because the Albanian banking system do not give loan in such case if the Rate of Return (ROR) is lower than 0.1 (10%). In the Table 6 are showed the NPV values for different scenarios, based in different Cash Flow (CF). From this table can be seen that the NPV become positive for CF greater than 350 000 €/y. In the

Figure 10, is showed the chart of PV/time, while in the Figure 11, the chart of (NPV/CF). The analytical analyses (and also graphical) shows that the NPV is equalized to zero, only if the CF is 382 949 €/y. For lower CF the NPV result negative and of course for greater CF it will be positive. The business plan predict a CF of about 445 000 €/y, based in the Albanian touristic market and its prices.

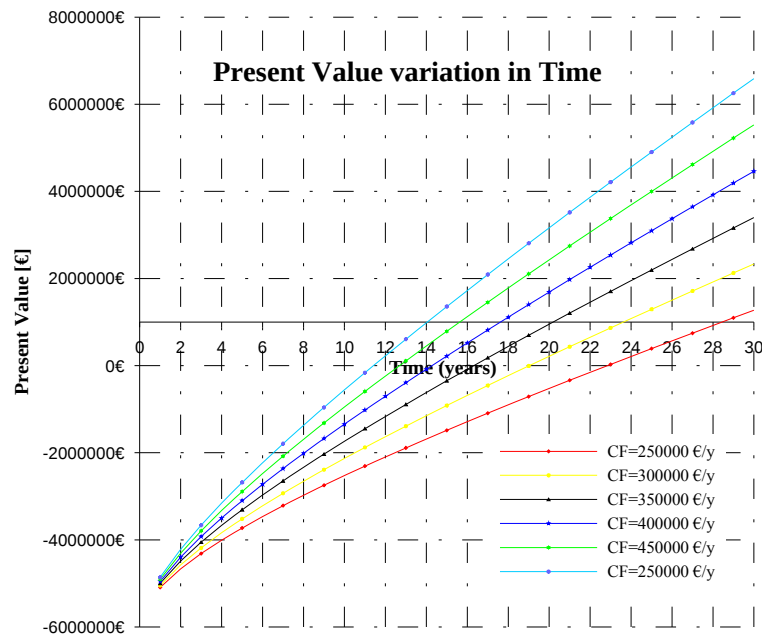


FIGURE 10 PRESENT VALUE VARIATIONS VERSUS TIME

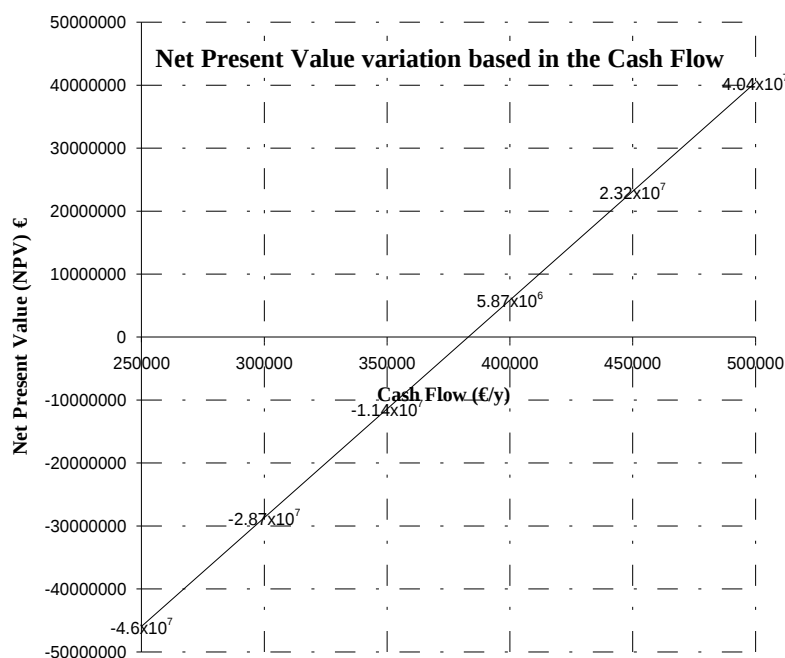


FIGURE 11 NET PRESENT VALUES FLUCTUATION BASED ON THE CASH FLOW

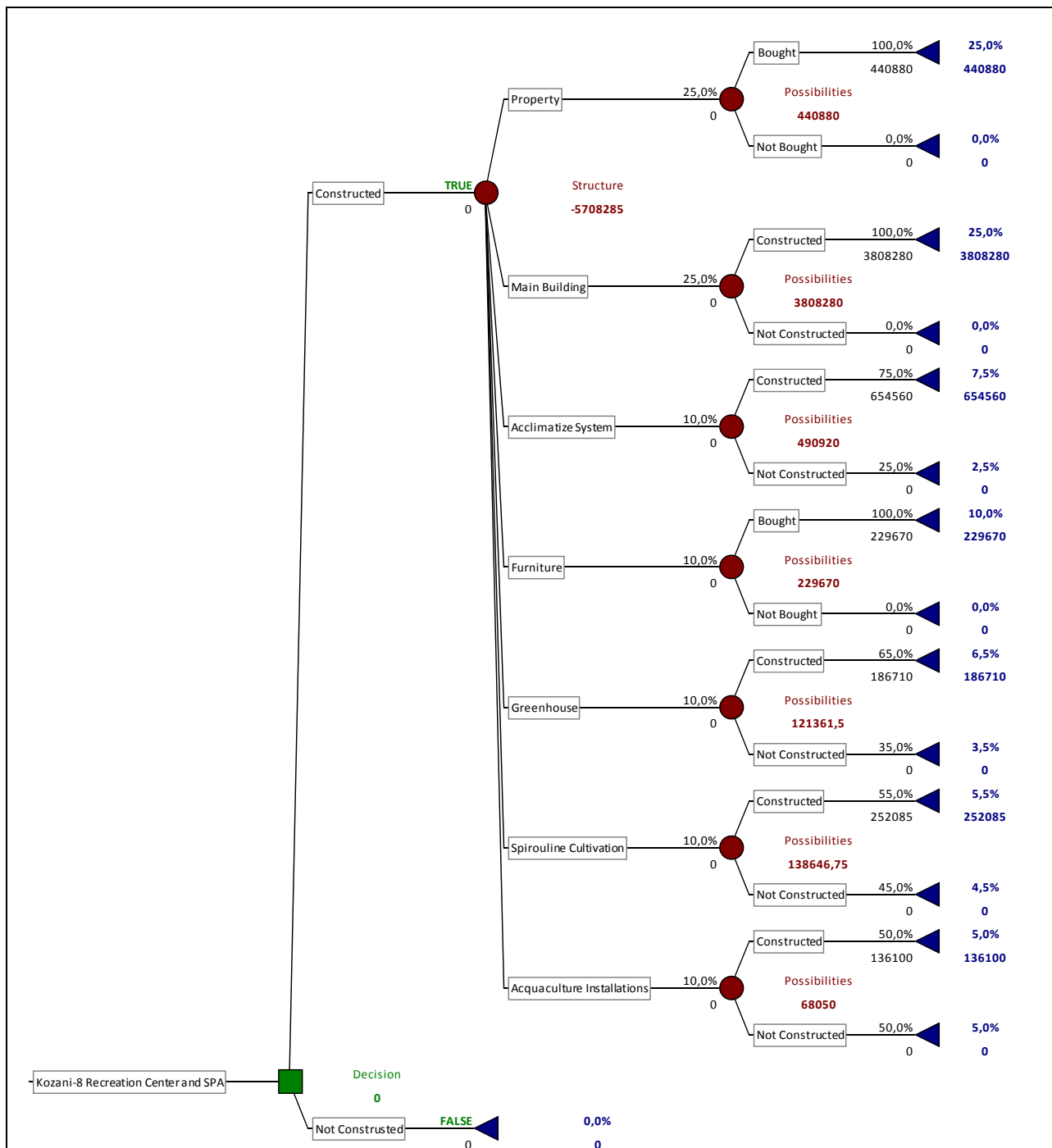


FIGURE 12 RISK ANALYSIS CHART FOR THE KOZANI-8 RECREATION CENTRE CONSTRUCTION

In the figure 12 is showed the chart of Risk Analyses. There can be seen even better that the risk is minimal, so the investment is totally efficient. In the following charts, Figure 13 is possible to see the risk for each value of NPV. So once more the risk is minimal, and the investment is very profitable.

### Conclusions

The Kozani-8 water temperature is suitable for the supply of a recreational center, including geothermal indoor and outdoor pools;

1. The water temperature is suitable for feeding of two cascades;
2. The hybrid system will improve the economic efficiency of the project;
3. The construction of the center will improve the energetic balance of the region;
4. The construction of the center will help on diversifying the energy resources in Albania;
5. The degasified and desalination line will improve the environmental status of the area, as actually is highly polluted;



6. It will improve the living standards of the community;

7. The economic analyses show that it is feasible.

8. The risk analysis shows very optimistic data's for the future of the investment.

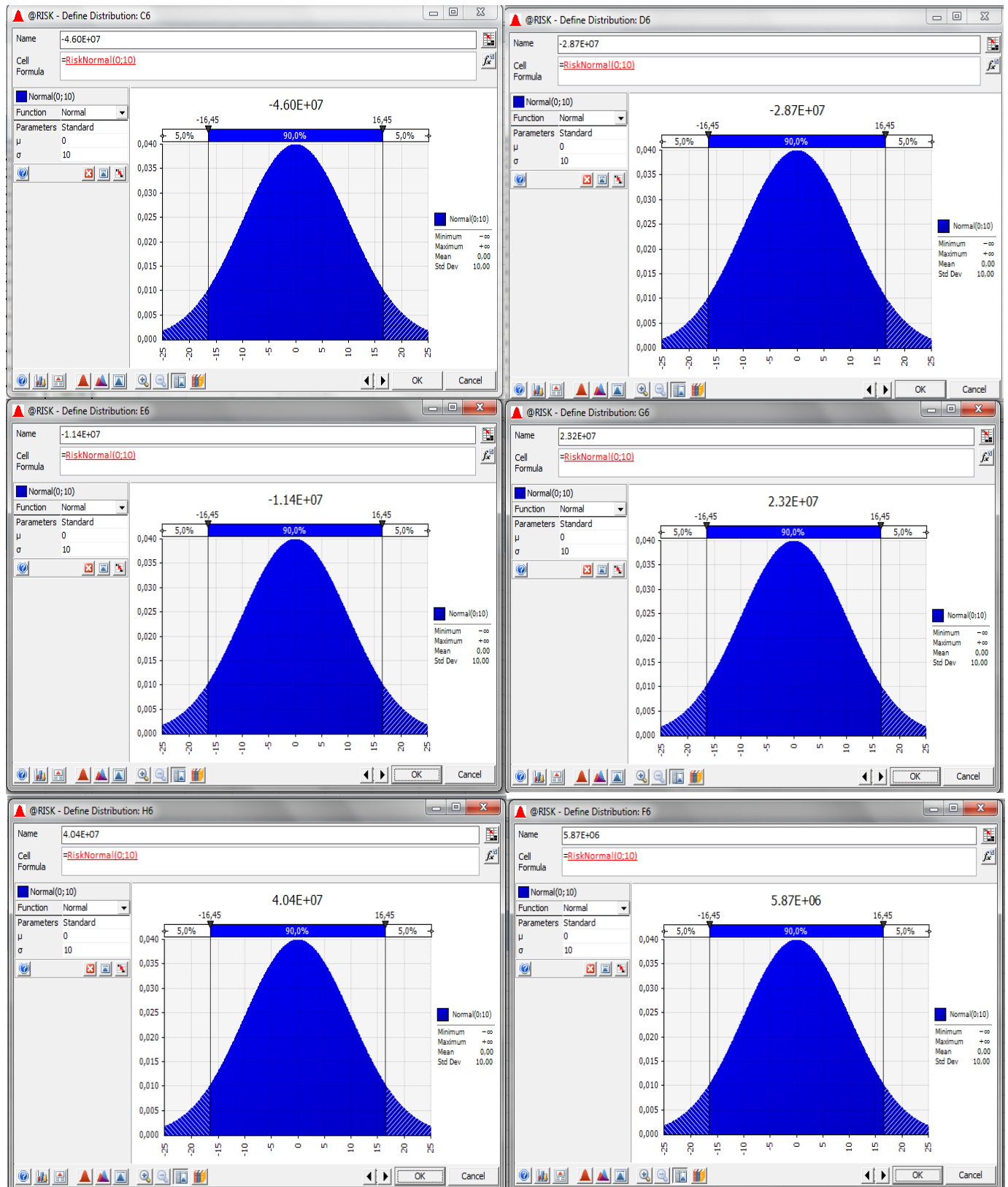


FIGURE 13 RISK ANALYSES CHART BASED ON THE NPV

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